Evidence of Light Reception Through the Shell of *Notoacmea persona* (Rathke, 1833)

(Archaeogastropoda : Acmaeidae)

BY

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(1 Plate; 4 Text figures)

INTRODUCTION

The limpet *Notoacmea persona* (Rathke, 1833) ranges from the Shumagin Islands, Alaska to Morro Bay, California (McLean, 1966: 101). A high intertidal species (+0.9m to +1.5m above datum), *N. persona* is found in deep crevices, caves, and on the exposed undersides of large boulders. This species is negatively phototropic, venturing from these habitats at night to feed (Test, 1933: 43).

The exterior surface of the shell is olivaceous green and typically covered with scattered white markings. The white markings on the anterior and antero-lateral areas are translucent and usually larger than the posterior markings which are opaque (Figure *1*). In view of the presence of translucent shell material directly over the head region of the limpet, the present study was undertaken to determine if light impinging on the anterior surface of the shell is detected by this species.

METHODS AND MATERIALS

Eleven limpets were collected 800m north of the Pacific Marine Station, Dillon Beach, Marin County, California; 12 additional *Notoacmea persona* were collected at Miller's Fishing Access on the east side of Tomales Bay, Marin County, California, about 8km south of Dillon Beach. Rocks from the habitat were also collected at the Dillon Beach site to provide food during the experiments.

Tests were conducted in a fiberglass, plywood trough with a clear glass partition at one end for housing the light source. Refrigerated seawater (13° C) was circulated from a fiberglass holding tank through the test trough and back to the holding tank. Water depth in the trough was maintained at 2.5cm to insure complete immersion of the limpets. Illumination was provided by a 25 watt tungsten filament lamp.

Light intensity readings were obtained in the field with a Weston Model 703 Footcandle Meter equipped with a Model 856 G-B Cell Probe. Readings were taken, with the probe held parallel and adjacent to the substrate, during bright sunny days (mean, 80 footcandles) and on foggy days (mean, 10 footcandles). We arrived at the illumination intensity employed in the experiments (40 footcandles) by averaging the observed field readings. The 40 footcandles reading is not intended to represent a daily, monthly, or annual mean of illumination but a value which would insure that the test illumination did not exceed the limits of natural conditions. To duplicate this intensity in the test trough, the footcandle meter was moved along the bottom of the trough until a 40 footcandles reading was obtained. This distance was 15cm from the light source.

Tests were conducted every other day to prevent the habituation to illumination noted by Ross (1968: 26) with the limpet *Collisella limatula* (Carpenter, 1864). Limpets were kept dark for 8 hours preceding the tests. The shells were numbered with India ink on a nail polish dot placed on the posterior slope.

In the 3 tests conducted, the limpet was placed 15cm from the light source in the darkened trough (anterior end towards the light source), allowed to adapt for 5 minutes, and then artificially illuminated.

Test 1 was conducted with the entire shell exposed to illumination.

In test 2, oblique cones were constructed from black, opaque polyethylene and each was marked with an embossed plastic tape number. These hoods were affixed to the apex of the shell of each specimen by a spot of sili-

cone seal. The hood was then trimmed to match the edge of the shell, insuring that no contact existed between the hood and the limpet other than the surface of the shell. These hoods prevented light from impinging on the surface of the shell. Specimens were not handled for 24 hours after attaching the hoods to allow the silicone seal to cure. Of the 23 limpets fitted with hoods, 5 hoods were found detached at the end of the 24 hour period.

In test 3 the anterior sections of the hoods were removed to allow illumination of the translucent portion of the shell. This test was designed to determine if the presence of the hoods, and not the blocking of the light, would alter the response time.

Response time is defined as the time required for the animal to turn more than 90° away from the directional light source. A time limit of 200 seconds, based on preliminary field and laboratory experiments, was allowed for the limpets to respond.

After testing was completed, the animals were killed, removed from their shells, and the surface area of each shell determined. The amount of translucent material was ascertained by measuring the diameter and number of translucent spots per shell. Radial sections of the shell were also prepared, one each from the anterior and posterior ends.

RESULTS

A control group of 10 limpets was placed in the test trough under ambient room illumination and artificially oriented in different directions to observe any natural responses to the trough. In the 15 minutes allowed, none of the 10 limpets tested showed any definite turning response.

In test 1 (entire shell exposed) mean response time was 72.8 seconds with a standard deviation of 39.4 seconds. In test 2 (hooded) mean response time was 120.9 seconds ±49.1 seconds and in test 3 (anterior end only exposed) mean response time was 81.0 ± 30.0 seconds.

The response of *Notoacmea persona* to light was the same as noted by Ross (1968: 25) for *Collisella limatula*. In addition to the turning and slight backing movements, *N. persona* was observed to cant the shell and place the edge of the illuminated section against the bottom of the trough. This position was maintained throughout the entire turning movement. Extension and movement of the cephalic tentacles was also evident.

Sections of the shell of *Notoacmea persona* revealed 2 types of shell material: a white, translucent material, and a brown, opaque material. The placement of these 2 types of shell material was found to be the determinant as to whether the marking was translucent or opaque (Figure 2).

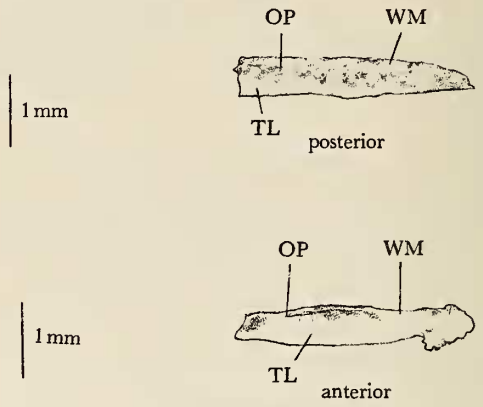

Figure 2

Radial sections of the shell of *Notoacmea persona*
OP – opaque layer TL – translucent layer WM– white marking
Drawings by S. Graves

The anterior portion of the shell is composed of an inner translucent layer and an outer opaque layer. Where there are white markings on the surface of the shell the outer opaque layer is absent. The posterior portion of the shell is also composed of an inner translucent and an outer opaque layer. However, white markings are the result of white shell material deposited on the surface of the opaque layer. Light striking an anterior marking is diffused to the interior of the shell, while light impinging upon a posterior marking is blocked from the interior of the shell by the underlying opaque layer.

DISCUSSION

The results of these tests indicate an increase in response time when light is prevented from passing through the translucent portion of the shell (see Table 1).

Seven limpets in both tests 1 and 2, and 8 in test 3 failed to show a definite turning response in the allotted time. In all but 2 cases, the limpets were turning at the end of the time limit. It may be that under stronger illumination, such as used in our preliminary experiments and in some of the experiments conducted by Ross (1968), all limpets would have responded. However, field conditions seldom attain the maximum limit of the ob-

Figure 1 a

Figure 1 b

Figure 1: Shell of *Notoacmea persona* (Rathke, 1833), anterior end towards the top of the figure. a: dorsal illumination, b: ventral illumination. Photographs by Maurice Giles, California Academy of Sciences.